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OPTIMIZATION OF THE PROCESS PARAMETER IN DRILLING OF GFRP USING HSS DRILL

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ABSTRACT

Fabrication and assembly of parts requires drill holes. The importance of better productivity of the Air craft parts while assembling of polymer composite to avoid the rejection process in drilling operation. The drilling operation of machining process is very important in production of aircraft components due to drilling operation 60% of rejection due to delamination. To minimize the rejection of components the selection of process parameters are required. Designs of experiments were conducted using milling machine and modelling analysis used by regression model and Taguchi technique. From the experimental results, feed rate is the most important parameter for delamination.

KEYWORDS: Drill Holes, Design, Machine, Experiment and Parameters

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Original Article

INTRODUCTION

GFR widely used because they have excellent properties, such as high specific strength, high specific modulus of elasticity, light weight, good corrosion resistance, [1]. Delamination is a major problem in peel up and push out delamination [2]. Due to composite materials anisotropy and in homogeneity [3-4], posses 60% of rejection in GFRP during assembling, with aircraft component causes delamination **[5].** The delamination factor F_d, as shown in Figure 2.1, which can be defined as the ratio of the maximum diameter D_{max} of the observed delamination zone to the nominal diameter D_{nom} of the drilled hole [6].

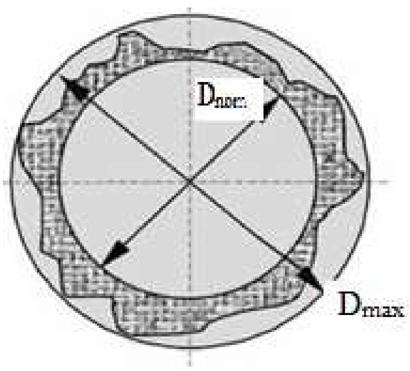

Figure 1: Scheme of Delamination

$$F_d = \frac{D_{max}}{D_{nom}} \tag{1}$$

D_{max} = maximum diameter in mm

D_{nom} = nominal diameter in mm

However, the criterion based on F_d may generally have an inherent incoherence because the extent of the delamination caused by just a few fibers peeled up or pushed down to a distinct significant width does not depict truly the real delamination zone of the drilled hole periphery.

EXPERIMENTAL SET-UP

Figure.2: Vertical Machining Centre

Drilling experiment was conducted in vertical machining centre. Dynamometer Kistler type 9257B and related amplifier, in order to measure machining forces. This dynamometer is capable of measuring forces and moments in three directions. Standard high speed steel drill bits 6 mm. Woven GFRP laminate with 13 layers and total thickness of 8 mm and epoxy resin as the matrix and E-Glass fibre is reinforcement.

Design of experiments (Taguchi method) Taguchi method of designing experiments has been used widely by engineers and industries in order tom obtain information about the effects of different factors on a given process. This technique is based on orthogonal arrays to reduce number of experiment to be executed. Based on Design of experiments drilling was conducted using vertical machining centre (VMC). Modelling and analysing done using regression model and Taguchi. Delamination measured by using profile projector. From the experiment results it was concluded that the feed rate is most influenced parameter in drilling induced de lamination.

Table1: Selected Factors and Levels

Level	Spindlespeed (Rpm)	Feed Rate (Mm/Rev)
1	500	0.1
2	1000	0.15
3	1500	0.2

REGRESSION MODELING

Regression Equation in conventional drilling

Delamination factor= -0.4510 + 0.000008 Speed (rpm) + 0.611 Feed rate (mm/rev) (1)

The above equations (4.3) define the regression equation of delamination factor in conventional drilling. We use in this equation predict delamination factor corresponding input parameters. In this regression modelling delamination Factor equation accuracy 84.68 percentages. We obtained relationship between independent parameters and dependent parameters. Dependent parameter denoted by output and independent parameter denoted by input parameters.

Table 2: Experimental and Predicted Values in Conventional Drilling

Expt. No.	Spindle Speed	Feed Rate	Actual Delamination Factor	Regression
1	500	0.1	1.64	1.610
2	1000	0.15	1.667	1.678
3	1500	0.2	1.729	1.756
4	500	0.15	1.625	1.619
5	1000	0.2	1.750	1.688
6	1500	0.1	1.792	1.767
7	500	0.15	1.604	1.628
8	1000	0.1	1.708	1.699
9	1500	0.15	1.750	1.779

Experimental and predicted values in conventional drillings shown in Table 3. Error calculated using equation 3. find the difference between fitted delamination factor in conventional drilling and Measured Delamination factor in conventional drilling divided by fitted delamination factor in conventional drilling.

Table 3: Analysis of Variance for SN Ratios

Source	DF	Seq SS	Adj SS	Adj MS	F	P	Percentage of Contribution
Speed(rpm)	2	0.12118	0.12118	0.060592	9.24	0.032	11.76
Feed rate(mm/rev)	2	0.88251	0.88251	0.441254	67.30	0.001	85.68
Residual Error	2	0.02623	0.02623	0.006557			
Total	8	1.02992					

Analysis of Variance for SN ratios in conventional drilling is Shown in Table 5. Based on ANOVA, we find which factors mostly influence than the other factor, for particular output. Feed rate is most influence parameter 85.687 percentages compare to the other parameters amplitude and speed. Speed influence the output 11.76 percentage and amplitude influence less compare to the other parameter. It is influenced only 0.96 percentages.

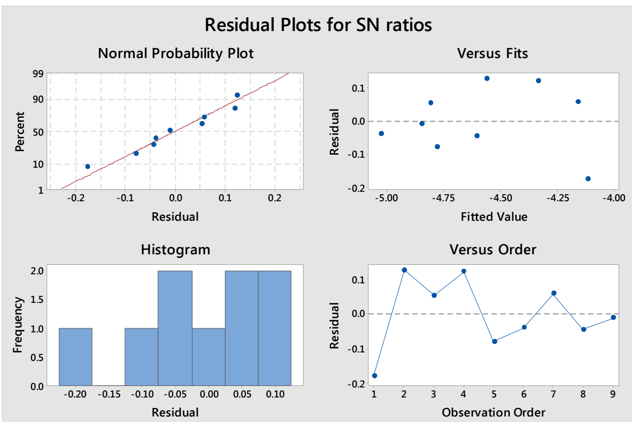

Figure 3: Residual Plots for SN Ratios

Table 4: Response Table for SN Ratios

Level	Spindle Speed (rpm)	Feed Rate (m/sec)
1	-4.497	-4.206
2	-4.715	-4.650
3	-4.538	-4.894
Delta	0.218	0.688
Rank	2	1

Analysis of Response Table for SN Ratios in conventional drilling Shown in Table 6. from the table we understand Feed rate is mostly influenced parameters compare to the other parameters. Rank given based on delta value. Higher delta value is given rank one.

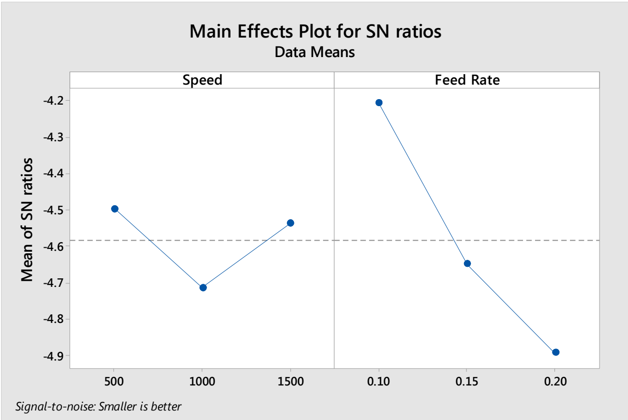

Figure 4: Main Effects Plots for SN Ratios

Main Effects Plots for SN ratios in conventional drilling shown in Figure 5 for terms that represent main effects, the table displays the groups within each factor and their fitted means. The optimal conditions are A1B1from SN ratio.

CONFIRMATION EXPERIMENT

Table 5: Analysis of Variance Transformed Response

Source	DF	Adj SS	Adj MS	F-Value	P-Value	Percentage of Contribution
Speed (rpm)	1	0.000106	0.000106	0.6	0.468	1.56
Feed rate(mm/rev)	1	0.005606	0.005606	31.64	0.001	82.75
Error	6	0.001063	0.000177			15.69
Total		**0.006775**				

Analysis of Variance for Transformed Response in conventional drilling is Shown in Table 2. Based on ANOVA, we find which factor mostly influence than the other factor for particular output. Speed is 82.75 percentages most influence parameter, compared to the feed rate. Feed rate influenced 15.69 percentages the output (delamination factor in conventional drilling) R-sq 84.31%. R^2 is the percentage of variation in the response, that is explained by the model. It is calculated as 1 minus the ratio of the error sum of squares (which is the variation that is not explained by model) to the total sum of squares (which is the total variation in the model)

CONCLUSIONS

The process parameters optimization is very important for drilling process. Regression modelling and Taguchi analysis was done, by using mini tab 17 software. The optimal conditions are A1B, speed 500 rpm and feed 0.1 mm/rev

suitable for drilling in conventional drilling, by using HSS tool.

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